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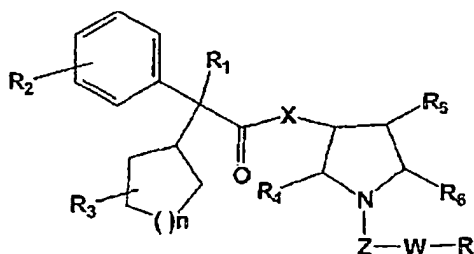
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(54) Title: 1-SUBSTITUTED-3-PYRROLIDINE DERIVATIVES AS MUSCARINIC RECEPTOR ANTAGONISTS



(I)

(57) Abstract: This invention generally relates to the derivatives of 1-substituted-3-pyrrolidines having the structure of Formula (I). The compounds of this invention can function as muscarinic receptor antagonists, and can be used for the treatment of various diseases of the respiratory, urinary and gastrointestinal systems mediated through muscarinic receptors. The invention also relates to a process for the preparation of the compounds of the present invention, pharmaceutical compositions containing the compounds of the present invention and the methods for treating the diseases mediated through muscarinic receptors.

# 1-SUBSTITUTED-3-PYRROLIDINE DERIVATIVES AS MUSCARINIC RECEPTOR ANTAGONISTS

## FIELD OF THE INVENTION

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This invention generally relates to the derivatives of 1-substituted-3-pyrrolidines.

The compounds of this invention can function as muscarinic receptor antagonists, and can be used for the treatment of various diseases of the respiratory, urinary and  
10 gastrointestinal systems mediated through muscarinic receptors.

The invention also relates to a process for the preparation of the compounds of the present invention pharmaceutical compositions containing the compounds of the present invention and the methods for treating the diseases mediated through muscarinic receptors.

15

## BACKGROUND OF THE INVENTION

Muscarinic receptors as members of the G Protein Coupled Receptors (GPCRs) are composed of a family of 5 receptor sub-types ( $M_1$ ,  $M_2$ ,  $M_3$ ,  $M_4$  and  $M_5$ ) and are activated  
20 by the neurotransmitter acetylcholine. These receptors are widely distributed on multiple organs and tissues and are critical to the maintenance of central and peripheral cholinergic neurotransmission. The regional distribution of these receptor sub-types in the brain and other organs has been documented. For example, the  $M_1$  subtype is located primarily in neuronal tissues such as cerebral cortex and autonomic ganglia, the  $M_2$  subtype is present  
25 mainly in the heart where it mediates cholinergically induced bradycardia, and the  $M_3$  subtype is located predominantly on smooth muscle and salivary glands (Nature, 1986; 323: 411; Science, 1987; 237: 527).

A review in Current Opinions in Chemical Biology, 1999; 3: 426, as well as in Trends in Pharmacological Sciences, 2001; 22: 409 by Eglen et. al., describe the biological  
30 potentials of modulating muscarinic receptor subtypes by ligands in different disease conditions like Alzheimer's disease, pain, urinary disease condition, chronic obstructive pulmonary disease etc.

A review in J. Med. Chem., 2000; 43: 4333 by Christian C. Felder et. al. describes therapeutic opportunities for muscarinic receptors in the central nervous system and elaborates on muscarinic receptor structure and function, pharmacology and their therapeutic uses.

- 5           The pharmacological and medical aspects of the muscarinic class of acetylcholine agonists and antagonists are presented in a review in Molecules, 2001, 6: 142.

N.J.M. Birdsall et. al. in Trends in Pharmacological Sciences, 2001; 22: 215 have also summarized the recent developments on the role of different muscarinic receptor subtypes using different muscarinic receptors of knock out mice.

- 10           Muscarinic agonists such as muscarine and pilocarpine and antagonists such as atropine have been known for over a century, but little progress has been made in the discovery of receptor subtype-selective compounds making it difficult to assign specific functions to the individual receptors. Although classical muscarinic antagonists such as atropine are potent bronchodilators, their clinical utility is limited due to high incidence of  
15 both peripheral and central adverse effects such as tachycardia, blurred vision, dryness of mouth, constipation, dementia, etc. Subsequent development of the quarterly derivatives of atropine such as ipratropium bromide are better tolerated than parenterally administered options but most of them are not ideal anti-cholinergic bronchodilators due to lack of selectivity for muscarinic receptor sub-types. The existing compounds offer limited  
20 therapeutic benefit due to their lack of selectivity resulting in dose limiting side-effects such as thirst, nausea, mydriasis and those associated with the heart such as tachycardia mediated by the M<sub>2</sub> receptor.

- Annual review of Pharmacological Toxicol., 2001; 41: 691, describes the pharmacology of the lower urinary tract infections. Although anti muscarinic agents such  
25 as oxybutynin and tolterodine that act non-selectively on muscarinic receptors have been used for many years to treat bladder hyperactivity, the clinical effectiveness of these agents has been limited due to the side effects such as dry mouth, blurred vision and constipation. Tolterodine is considered to be generally better tolerated than oxybutynin. (W.D.Steers et. al. in Curr. Opin. Invest. Drugs, 2: 268, C.R. Chapple et. al. in Urology,  
30 55: 33), Steers WD, Barrot DM, Wein AJ, 1996, Voiding dysfunction: diagnosis

classification and management. In "Adult and Pediatric Urology," ed. JY Gillenwatter, JT Grayhack, SS Howards, JW Duckett, pp 1220-1325, St. Louis, MO; Mosby. 3<sup>rd</sup> edition.)

Despite these advances, there remains a need for development of new highly selective muscarinic antagonists which can interact with distinct subtypes, thus avoiding the occurrence of adverse effects.

Compounds having antagonistic activity against muscarinic receptors have been described in Japanese patent application Laid Open Number 92921/1994 and 135958/1994; WO 93/16048; U.S. Patent No. 3,176,019; GB 940,540; EP 0325 571; WO 98/29402; EP 0801067; EP 0388054; WO 9109013; U.S. Patent No. 5,281,601. U.S. Patent Nos. 6,174,900, 6,130,232 and 5,948,792; WO 97/45414 are related to 1,4-disubstituted piperidine derivatives; WO 98/05641 describes fluorinated, 1,4-disubstitued piperidine derivatives; WO 93/16018 and WO96/33973 are other close art references.

A report in J. Med. Chem., 2002; 44:984, describes cyclohexylmethyl piperidinyl triphenylpropioamide derivatives as selective M<sub>3</sub> antagonist discriminating against the other receptor subtypes.

PCT applications WO 98/00109; 98/00132; 98/00133 and 98/00016 disclose isomers of glycopyrolate.

20

### SUMMARY OF THE INVENTION

The present invention provides 1-substituted-3-pyrrolidines which function as muscarinic receptor antagonists and are useful as safe and effective therapeutic or prophylactic agents for the treatment of various diseases of the respiratory, urinary and gastrointestinal systems and process for the synthesis of the compounds.

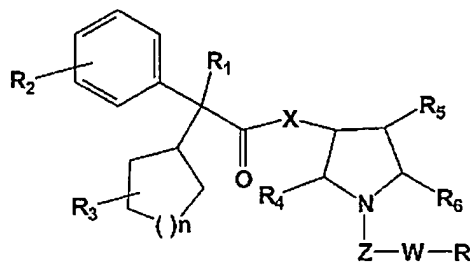
The invention also provides pharmaceutical compositions containing the compounds, and which may also contain acceptable carriers, excipients or diluents which are useful for the treatment of various diseases of the respiratory, urinary and gastrointestinal systems.

The invention also includes the enantiomers, diastereomers, polymorphs, pharmaceutically acceptable salts, pharmaceutically acceptable solvates, esters, N-oxides and metabolites of these compounds having the same type of activity.

The invention further includes pharmaceutical compositions comprising the compounds of the present invention, their esters, metabolites, enantiomers, diastereomers, N-oxides, polymorphs, pharmaceutically acceptable salts or pharmaceutically acceptable solvates, in combination with a pharmaceutically acceptable carrier and optionally included excipients.

Other advantages of the invention will be set forth in the description which follows, and in part will be apparent from the description or may be learnt by the practice of the invention. The objects and the advantages of the invention may be realized and obtained by means of the mechanisms and combinations pointed out in the appended claims.

In accordance with one aspect of the present invention, there is provided a compound having the structure of Formula I:



Formula I

and its pharmaceutically acceptable salts, pharmaceutically acceptable solvates, esters, enantiomers, diastereomers, N-oxides, polymorphs, prodrugs, or metabolites, wherein

X represents an oxo, amino, lower alkyl(C<sub>1</sub>-C<sub>4</sub>)amino or lower alkoxy (C<sub>1</sub>-C<sub>4</sub>);

R<sub>1</sub> represents hydroxy, amino, or alkoxy (OR<sub>7</sub>), wherein R<sub>7</sub> represents lower alkyl;

R<sub>2</sub> represents hydrogen, halogen (e.g. fluorine, chlorine, bromine and iodine) or lower alkyl;

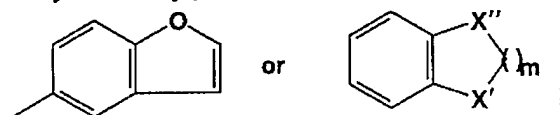
R<sub>3</sub> represents hydrogen, keto, hydroxy, sulphonyl methane, tosyl, azide, amino or substituted amine (NHR<sub>8</sub>) where R<sub>8</sub> represents hydrogen or YR<sub>9</sub>, wherein R<sub>9</sub> represents benzyl, benzyloxy, alkyl, benzyl ether, phenyl optionally substituted with alkyl, trifluoromethyl, nitro or halogen (e.g. fluorine, chlorine, bromine, iodine);

Z represents methylene, sulphonyl or carbonyl;

W represents a direct link of (CH<sub>2</sub>)<sub>n</sub>, where n is 1 or 2, lower alkoxy (C<sub>1</sub>-C<sub>4</sub>) or lower thioalkoxy (C<sub>1</sub>-C<sub>4</sub>);

R represents alkyl, aryl, aralkyl, benzyl ether, dimethyl ether, methoxy methyl, benzyl methyl ether or phenyl optionally substituted with alkyl, halogen (e.g. fluorine, chlorine, bromine, iodine), nitro, heterocycle selected from the group consisting of pyridinyl, pyrazinyl or thienyl;

15



wherein X' and X'' are each independently selected from the group consisting of oxygen, methylene; m represents 1 to 3; and

R<sub>4</sub>, R<sub>5</sub> and R<sub>6</sub> represent hydrogen or lower alkyl.

In accordance with a second aspect of the present invention, there is provided a method for treatment or prophylaxis of an animal or human suffering from a disease or disorder of the respiratory, urinary and gastrointestinal systems, wherein the disease or disorder is mediated through muscarinic receptors, comprising administering to a patient in need thereof, an effective amount of compounds as described above.

In accordance with a third aspect of the present invention, there is provided a method for treatment or prophylaxis of an animal or human suffering from a disease or disorder associated with muscarinic receptors, comprising administering to a patient in need thereof, an effective amount of compounds as described above.

5 In accordance with a fourth aspect of the present invention, there is provided a method for treatment or prophylaxis of an animal or human suffering from a disease or disorder of the urinary system which induce such urinary disorders as urinary incontinence, lower urinary tract symptoms (LUTS), etc.; respiratory system such as bronchial asthma, chronic obstructive pulmonary disorders (COPD), pulmonary fibrosis,  
10 etc; and gastrointestinal system such as irritable bowel syndrome, obesity, diabetes and gastrointestinal hyperkinesis with compounds as described above, wherein the disease or disorder is associated with muscarinic receptors.

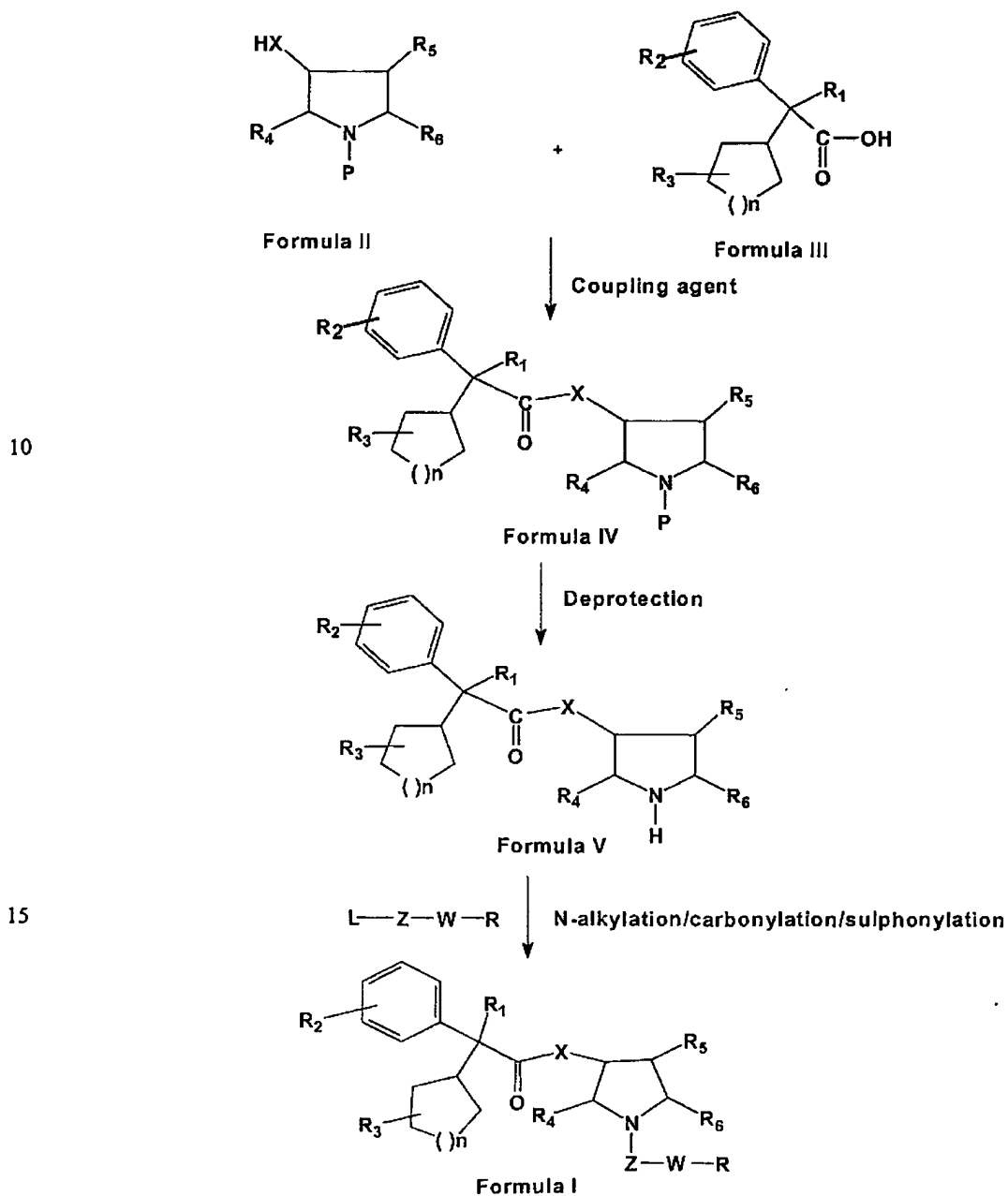
In accordance with a fifth aspect of the present invention, there is provided a process for preparing the compounds as described above.

15 The compounds of the present invention exhibit significant potency in terms of their activity, which was determined by *in vitro* receptor binding and functional assays and *in vivo* experiments using anaesthetized rabbit. Compounds were tested *in vitro* and *in vivo*. Some compounds were found to function as potent muscarinic receptor antagonists with high affinity towards M<sub>3</sub> receptors. Therefore, the present invention provides  
20 pharmaceutical compositions for treatment of the diseases or disorders associated with muscarinic receptors. Compounds and compositions described herein can be administered orally or parenterally.

**DETAILED DESCRIPTION OF THE INVENTION**

The compounds described herein may be prepared by techniques well known in the art and familiar to the average synthetic organic chemist. In addition, the compounds described herein may be prepared by the following reaction sequence:

5

**Scheme I**

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The compounds of Formula I of the present invention may be prepared by the reaction sequence as shown in scheme I. The preparation comprises coupling a compound of Formula II with the compound of Formula III wherein

X represents an oxo, amino, lower alkyl(C<sub>1</sub>-C<sub>4</sub>)amino or lower alkoxy (C<sub>1</sub>-C<sub>4</sub>);

5 R<sub>1</sub> represents hydroxy, amino, or alkoxy (OR<sub>7</sub>), wherein R<sub>7</sub> represents lower alkyl;

R<sub>2</sub> represents hydrogen, halogen (e.g. fluorine, chlorine, bromine and iodine) or lower alkyl;

10 R<sub>3</sub> represents hydrogen, keto, hydroxy, sulphonyl methane, tosyl, azide, amino or substituted amine (NHR<sub>8</sub>) where R<sub>8</sub> represents hydrogen or YR<sub>9</sub>, wherein R<sub>9</sub> represents benzyl, benzyloxy, alkyl, benzyl ether, phenyl optionally substituted with alkyl, trifluoromethyl, nitro or halogen (e.g. fluorine, chlorine, bromine, iodine);

R<sub>4</sub>, R<sub>5</sub> and R<sub>6</sub> represent hydrogen or lower alkyl;

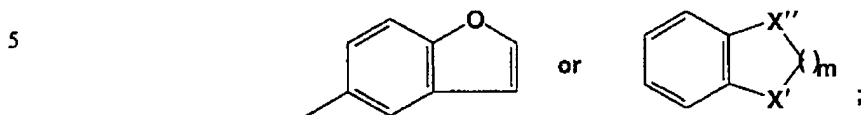
N is 1 or 2; and

15 P is any group, for example benzyl, t-butyloxycarbonyl, which can be used to protect an amino group in the presence of a coupling agent to give a protected compound of Formula IV, which on deprotection through reaction with a deprotecting agent in an organic solvent gives an unprotected compound of Formula V which is finally N-alkylated, carbonylated or sulphonylated with a suitable alkylating, carbonylating or sulphonylating agent of  
20 Formula L-Z-W-R to give a compound of Formula I, wherein L is a leaving group and

Z represents methylene, sulphonyl or carbonyl;

W represents a direct link of (CH<sub>2</sub>)<sub>n</sub>, where n is 1 or 2, lower alkoxy (C<sub>1</sub>-C<sub>4</sub>) or lower thioalkoxy (C<sub>1</sub>-C<sub>4</sub>); and

R represents alkyl, aryl, aralkyl, benzyl ether, dimethyl ether, methoxy methyl, benzyl methyl ether or phenyl optionally substituted with alkyl, halogen (e.g. fluorine, chlorine, bromine, iodine), nitro, heterocycle selected from the group consisting of pyridinyl, pyrazinyl or thienyl;



wherein  $X'$  and  $X''$  are each independently selected from the group consisting of oxygen, methylene; and  $m$  represents 1 to 3.

The reaction of the compound of Formula II with a compound of Formula III to give a compound of Formula IV can be carried out in the presence of a coupling agent, for example, N-methyl morpholine, hydroxy benzotriazole, 1-(3-dimethylaminopropyl)-3-ethyl carbodiimide hydrochloride (EDC. HCL) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU).

The reaction of the compound of Formula II with a compound of Formula III to give a compound of Formula IV can be carried out in a suitable solvent, for example, N,N-dimethylformamide, chloroform, dimethylsulphoxide, xylene and toluene.

The deprotection of the compound of Formula IV to give a compound of Formula V can be carried out in the presence of a deprotecting agent, for example, palladium on carbon, ammonium formate, trifluoroacetic acid and hydrochloric acid.

The deprotection of the compound of Formula IV to give a compound of Formula V can be carried out in a suitable solvent, for example, methanol, ethanol, tetrahydrofuran and acetonitrile at temperatures ranging from about 10 to about 50°C.

The N-alkylation, carbonylation or sulphonylation of the compound of Formula V to give a compound of Formula I can be carried out with a suitable alkylating, carbonylating, or sulphonylating agent, L-Z-W-R where L is any leaving group known in the art, for example halogen, O-mestyl, benzyl and O-tosyl group.

The N-alkylation or carbonylation or sulphonylation of the compound of Formula V to give a compound of Formula I can be carried out in a suitable solvent such as N, N-dimethylformamide, dimethylsulfoxide, tetrahydrofuran, acetonitrile and dichloromethane.

In the above scheme, where specific bases, coupling agents, protecting groups, deprotecting agents, N-alkylating, sulphonylating, carbonylating agents, solvents, catalysts etc. are mentioned, it is to be understood that other bases, coupling agents deprotecting agents, N-alkylating, sulphonylating, carbonylating agents, solvents etc. known to those skilled in art may be used. Similarly, the reaction temperature and duration may be adjusted according to the desired needs.

The pharmaceutically acceptable salts of the compounds of Formula I include acid addition salts such as hydrochloride, hydrobromide, hydrofluoric, sulphate, bisulfate, phosphate, hydrogen phosphate, acetate, brosylate, citrate, fumarate, glyconate, lactate, maleate, mesylate, succinate, and tartarate.

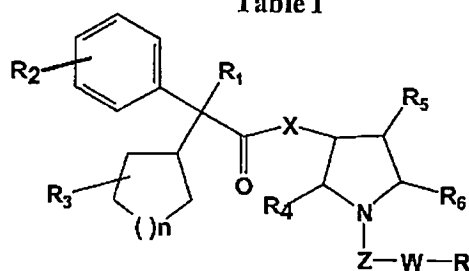
Quaternary ammonium salts such as alkyl salts, aralkyl salts, and the like, of the organic bases may be readily formed by treatment of the organic bases with the appropriate quaternary salts forming substances, which include, for example methyl chloride, methyl bromide, methyl iodide, methyl sulphate, methyl benzene sulphonate, methyl p-toluene sulphonate, ethyl chloride, ethyl bromide, ethyl iodide, n-propyl chloride, n-propyl bromide, n-propyl iodide, isopropyl bromide, n-butyl chloride, n-butyl bromide, isobutyl bromide, sec-butylbromide, n-amyl bromide, n-hexyl chloride, benzyl chloride, benzyl bromide, and ethyl sulphate.

Particular compounds which are capable of being produced by Scheme I and shown in Table I include:

Compound No.	Chemical Name
1.	2-cyclopentyl-2-hydroxy-N-[(3S)-1-benzyl-pyrrolidin-3-yl]-2-phenyl acetamide
2.	2-cyclopentyl-2-hydroxy-N-[(3S)-1-[2-(1,3-benzodioxol-5-yl)]-ethyl]pyrrolidin-3-yl]-2-phenyl acetamide

3. (3S)-1-benzylpyrrolidin-3-yl cyclopentyl(hydroxy)phenyl acetate
4. (3S)-1-[[2-(1,3-benzodioxol-yl)ethyl]pyrrolidin-3-yl]cyclopentyl(hydroxy)phenyl acetate
- 5 5. (3S)-1-[[2-(2,3-dihydro-1-benzofuran-5-yl)ethyl]pyrrolidin-3-yl]cyclopentyl-(hydroxy)phenyl acetate
6. (3S)-1-[(4-methyl-pent-3-enyl)pyrrolidin-3-yl] cyclopentyl(hydroxy)phenyl acetate
7. (3S)-1-[(4-trifluoromethylphenyl)sulfonyl]pyrrolidin-3-yl]cyclopentyl(hydroxy)phenyl acetate
- 10 8. (3S)-1-[(4-nitrophenyl)sulfonyl]pyrrolidin-3-yl]cyclopentyl(hydroxy)phenyl acetate
9. (3S)-1-benzyl-pyrrolidin-3-yl (2R)-hydroxy(3-oxocyclopentyl)phenyl acetate
10. (3S)-1-benzylpyrrolidin-3-yl (2R)-hydroxy(3-hydroxycyclopentyl)phenyl acetate
11. (3S)-1-[(phenylacetyl)pyrrolidin-3-yl] cyclopentyl(hydroxy)phenyl acetate
12. (3S)-1-[(benzyloxy)acetyl]pyrrolidin-3-yl]cyclopentyl(hydroxy)phenyl acetate
- 15 13. Benzyl (3S)-3-[(2-hydroxy-2-cyclopentyl-2-phenylpropanoyl)oxy]pyrrolidin-1-carboxylate
14. (3S)-1-[(4-bromophenyl)sulfonyl]pyrrolidin-3-yl]cyclopentyl(hydroxy)phenyl acetate
15. (3S)-1-benzylpyrrolidin-3-yl (2R)-cyclopentyl(hydroxy)phenyl acetate
- 20 16. (3S)-1-[[2-(2,3-dihydro-1-benzofuran-5-yl)ethyl]pyrrolidin-3-yl] (2R)cyclopentyl(hydroxy)phenyl acetate
17. (3S)-1-[[2-(1,3-benzodioxol-5-yl)ethyl]pyrrolidin-3-yl (2R)-cyclopentyl(hydroxy)phenyl acetate

Table I



Formula I

(wherein R<sub>1</sub>=OH, R<sub>2</sub>=R<sub>4</sub>=R<sub>5</sub>=R<sub>6</sub>=H, n=1)

Compound No.	Z-W-R	X	R <sub>3</sub>	Configuration at pyrrolidine	Configuration at Carbon attached to R <sub>1</sub>
1.		NH	H	S	RS
2.		NH	H	S	RS
3.		O	H	S	RS
4.		O	H	S	RS
5.		O	H	S	RS
6.		O	H	S	RS
7.		O	H	S	RS
8.		O	H	S	RS
9.		O	CO	S	RS
10.		O	OH	S	RS
11.		O	H	S	RS
12.		O	H	S	RS
13.		O	H	S	RS
14.		O	H	S	RS
15.		O	H	S	R
16.		O	H	S	R
17.		O	H	S	R

Compounds or compositions disclosed may be administered to an animal for treatment orally, or by a parenteral route. Pharmaceutical compositions disclosed herein can be produced and administered in dosage units, each unit containing a certain amount of at least one compound described herein and/or at least one physiologically acceptable addition salt thereof. The dosage may be varied over extremely wide limits as the compounds are effective at low dosage levels and relatively free of toxicity. The compounds may be administered in the low micromolar concentration, which is therapeutically effective, and the dosage may be increased as desired up to the maximum dosage tolerated by the patient.

The present invention also includes the enantiomers, diastereomers, N-oxides, polymorphs, solvates and pharmaceutically acceptable salts of these compounds as well as metabolites having the same type of activity. The present invention further includes pharmaceutical composition comprising the compounds of Formula I, their esters, metabolites, enantiomers, diastereomers, N-oxides, polymorphs, solvates or pharmaceutically acceptable salts thereof, in combination with pharmaceutically acceptable carrier and optionally included excipients.

The examples mentioned below demonstrate the general synthetic procedure as well as the specific preparation of the preferred compounds. The examples are provided to illustrate particular aspects of the disclosure and should not be constrained to limit the scope of the present invention as defined by the claims.

### EXPERIMENTAL DETAILS

Various solvents, such as acetone, methanol, pyridine, ether, tetrahydrofuran, hexane and dichloromethane were dried using various drying reagents according to the procedures well known in the literature. IR spectra were recorded as nujol mulls or a thin neat film on a Perkin Elmer Paragon instrument, Nuclear Magnetic Resonance (NMR) were recorded on a Varian XL-300 MHz instrument using tetramethylsilane as an internal standard.

### Example 1

#### Preparation of 2-cyclopentyl-2-hydroxy-N-[(3S)-1-benzyl-pyrrolidin-3-yl]-2-phenylacetamide (Compound No. 1)

##### Step 1: Preparation of (3R)-pyrrolidin-3-ol hydrochloride

- 5 The compound trans-4-hydroxy-L-proline (10.0 g, 76.3 mM) was taken in a mixture of anhydrous cyclohexanol (50.0 ml) and 2-cyclohexen-1-one (0.5 ml). The reaction mixture was heated at 155-160°C for about 11 hours. To the reaction mixture, ethanolic hydrochloric acid (70.0 ml) was added with constant stirring, and kept at 0-5°C overnight. The separated solid was filtered under nitrogen atmosphere, washed with ethyl acetate  
10 (10.0 ml) and dried under vacuum to get the title compound. Yield = 35% (3.3 g, 26.7 mM).

<sup>1</sup>H NMR (DMSO-d<sub>6</sub>): δ 9.57 (brs, 1H), 9.33 (brs, 1H), 5.00-5.75 (brs, 1H), 4.38 (s, 1H), 3.01-3.47 (m, 4H), 1.84-1.92 (m, 2H).

##### Step 2: Preparation of (3R)-1-benzyl-pyrrolidin-3-ol

- 15 The compound (3R)-pyrrolidin-3-ol hydrochloride (2.2 g, 17.8 mM) was dissolved in dichloromethane (25.0 ml) and triethylamine (5.0 ml, 35.6 mM) was added at room temperature with constant stirring for 5 minutes. Benzyl chloride (2.5 ml, 21.4 mM) was added to it in one lot at the same temperature followed by refluxing for 15 hours. The reaction mixture was diluted with chloroform and 1N sodium hydroxide (15.0 ml) was  
20 added with constant stirring for 10 minutes. The organic layer was separated and washed with aqueous sodium bicarbonate and brine solution. It was further dried over anhydrous sodium sulphate and concentrated to get the title compound. Yield = 44.4% (1.4 g, 7.9 mM).

- <sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 7.31-7.37 (m, 5H), 4.36-4.37 (m, 1H), 3.68 (s, 1H), 2.73-2.92 (m,  
25 1H), 2.72 (d, J = 10 Hz, 1H), 2.56-2.61 (m, 1H), 2.20-2.37 (m, 2H), 1.77-1.81 (m, 1H).

##### Step 3: Preparation of (3R)-1-benzyl-3-[(methylsulfonyl) oxy]pyrrolidine

The compound (3R)-1-benzyl-pyrrolidin-3-ol (1.0 g, 5.65 mM) was dissolved in triethylamine (2.0 ml, 14.3 mM), and dimethyl amino pyridine (DMAP) (0.002 g),

dichloromethane (20.0 ml) and methanesulfonyl chloride (0.9 ml, 11.7 mM) was added dropwise at 0-5°C. The reaction mixture was maintained at the same temperature for about half an hour. The reaction mixture was then stirred at room temperature for 2 hours. The reaction mixture was diluted with dichloromethane (50.0 ml), washed with saturated sodium bicarbonate and brine solution. It was further dried over anhydrous sodium sulphate and concentrated to get the title compound as oil. Yield = 95% (1.2 g, 5.38 mM). This material was used as such in the next step.

#### Step 4: Preparation of (3S)-1-benzyl-3-azidopyrrolidine

The compound (3R)-1-benzyl-3-[(methylsulfonyl) oxy]pyrrolidine (1.3 g, 5.8 mM) was dissolved in dimethylformamide (25.0 ml) and sodium azide (1.5 g, 23.3 mM) was added to it. The reaction mixture was maintained at 90-100°C for about 12 hours followed by cooling at room temperature. The reaction mixture was poured into cold water (150.0 ml) with constant stirring. The organic compound was extracted with ethyl acetate and washed with water and brine solution, dried over anhydrous sodium sulphate and concentrated to give the title compound. Yield = 78% (0.9 g, 4.5 mM). This material was used as such in the next step.

IR (DCM): 2100.8  $\text{cm}^{-1}$ .

#### Step 5: Preparation of (3S)-1-benzyl-3-aminopyrrolidine

The compound (3S)-1-benzyl-3-azidopyrrolidine (0.9 g, 4.5 mM) was dissolved in a mixture of tetrahydrofuran (36.0 ml) and water (7.0 ml). To it, triphenylphosphine (2.3 g, 8.9 mM) was added and the reaction mixture was refluxed for 7 hours. The reaction mixture was cooled to room temperature and tetrahydrofuran was evaporated under vacuum. The residue was taken in water (50.0 ml) and the pH was adjusted to about 2 and washed with chloroform. The pH of the aqueous solution was adjusted to about 12-13 with 1N sodium hydroxide and extracted with chloroform. The chloroform layer was washed with water and brine solution. It was further dried over anhydrous sodium sulphate and concentrated to give the title compound. Yield = 62% (0.5 g, 2.8 mM).

$^1\text{H}$  NMR ( $\text{CDCl}_3$ ):  $\delta$  7.21-7.32 (m, 5H), 3.60 (d,  $J=4.3$  Hz, 2H), 3.49-3.51 (m, 1H), 2.68-2.74m, 2H), 2.46-2.48 (m, 1H), 2.18-2.33 (m, 2H), 1.61 (s, 2H,  $-\text{NH}_2$ ), 1.48-1.50 (m, 1H).



**Step 6: Preparation of 2-cyclopentyl-2-hydroxy-N-[(3S)-1-benzyl-pyrrolidin-3-yl]-2-phenylacetamide (Compound No. 1)**

The compound 2-cyclopentyl-2-hydroxy-2-phenylacetic acid (0.52 g, 2.36 mM) and (3S)-1-benzyl-3-aminopyrrolidine (0.5 g, 2.84 mM) were dissolved in dimethylformamide (10.0 ml) and N-methylmorpholine (1.3 ml, 11.8 mM) was added into it followed by the addition of 1-hydroxybenzotriazole (0.32 g, 2.36 mM) at 0-5°C. The reaction mixture was maintained at 0-5°C for 1 hour and then at room temperature for 19 hours. The reaction mixture was poured into water (100.0 ml) with constant stirring. The organic compound was extracted with ethyl acetate. The ethyl acetate layer was washed with saturated sodium bicarbonate water and brine solution followed its drying and concentration over anhydrous sodium sulphate. The residue was purified by silica gel column chromatography using 10% methanol in chloroform to get the title compound. Yield = 95% (0.5g, 2.38 mM).

<sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 7.58-7.60 (m, 2H), 7.26-7.36 (m, 8H), 6.74-6.80 (m, -CONH), 4.32-4.35 (m, 1H), 3.54-3.62 (m, 2H), 2.79-3.00 (m, 3H), 2.47-2.49 (brs, 1H, OH), 2.09-2.28 (m, 2H), 1.54-1.62 (m, 9H).

**Example 2**

**Preparation of 2-cyclopentyl-2-hydroxy-N-[(3S)-1-[2-(1,3-benzodioxol-5-yl)ethyl]pyrrolidin-3-yl]-2-phenylacetamide (Compound No. 2)**

**Step 1: Preparation of 2-cyclopentyl-2-hydroxy-N-[(3S)-pyrrolidin-3-yl]-2-phenylacetamide**

The compound 2-cyclopentyl-2-hydroxy-N-[(3S)-1-benzyl-pyrrolidin-3-yl]-2-phenylacetamide (0.8 g, 2.12 mM) was dissolved in methanol (20.0 ml) and 10% palladium on carbon (0.2 g) is added. After hydrogenating at room temperature for 10 hours at 65-70 psi, the second lot of 10% palladium on carbon (0.2 g) was added and hydrogenation was continued for 10 more hours at 65-70 psi at room temperature. The reaction mixture was diluted with methanol and filtered through a bed of hyflo. The filtrate was concentrated under vacuum and used as such in the next step.

**Step 2: Preparation of 2-cyclopentyl-2-hydroxy-N-[(3S)-1-[2-(1,3-benzodioxol-5-yl)ethyl]pyrrolidin-3-yl]-2-phenylacetamide (Compound No. 2)**

The compound 2-cyclopentyl-2-hydroxy-N-[(3S)-pyrrolidin-3-yl]-2-phenylacetamide (0.3 g, 1.04 mM) was dissolved in acetonitrile (5.0 ml). To this, 5-(2-bromoethyl)-1, 3-benzodioxole (0.28 g, 1.25 mM), potassium carbonate (0.43 g, 3.12 mM) and potassium iodide (0.34 g, 2.8 mM) were added and the reaction mixture was heated under reflux for 9 hours. The reaction mixture was cooled to room temperature and acetonitrile was evaporated under vacuum. The residue was partitioned between ethyl acetate (50.0 ml) and water (50.0 ml). The ethyl acetate layer was washed with water and brine solution and dried over anhydrous sodium sulphate and concentrated. The residue was purified by silica gel column chromatography using 20% methanol in chloroform to get the title organic compound as an oil. Yield = 64% (0.29 g, 0.67 mM).

<sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 7.60 (d, J = 7.5 Hz), 7.28-7.36 (m, 3H), 6.88 (br s, 1H, - CONH), 6.58-6.75 (m, 3H), 5.92 (d, J = 1 Hz, 2H), 4.36-4.38 (m, 1H), 3.35-3.65 (brm, 1H), 2.88-3.03 (brm, 2H), 2.60-2.66 (m, 4H), 2.53 (m, 1H), 2.23-2.25 (m, 2H), 1.80 (brs, 1H, -OH), 1.55-1.66 (m, 9H).

**Example 3**

**Preparation of (3S)-1-benzyl-pyrrolidin-3-yl cyclopentyl (hydroxy) phenylacetate (Compound No. 3)**

The compound 2-cyclopentyl-2-hydroxy-2-phenylacetic acid (0.3 g, 1.36 mM), (3R)-1-benzyl-pyrrolidin-3-ol (0.2 g, 1.14 mM) and triphenylphosphine (0.36 g, 1.36 mM) were dissolved in dry tetrahydrofuran (10.0 ml). To this, a solution of diethylazabicyclohexanecarboxylate (0.2 ml, 1.36 mM) in dry tetrahydrofuran (2.0 ml) was added dropwise under nitrogen atmosphere at room temperature with constant stirring and the stirring was continued for 20 hours. Tetrahydrofuran was evaporated under vacuum and the residue was taken in chloroform and washed with saturated sodium bicarbonate solution, water and brine solution followed by drying and concentrating over anhydrous sodium sulphate. The residue was purified by silica gel column chromatography using 30% ethyl acetate in hexane to get the title compound as oil. Yield = 91% (0.39 g, 1.03 mM).

<sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 7.64-7.67 (m, 2H), 7.26-7.35 (m, 8H), 5.17-5.23 (m, 1H), 3.56-3.74 (m, 3H), 2.75-2.90 (m, 4H), 2.00-2.52 (m, 3H, including-OH), 1.29-2.00 (m, 8H).

#### Example 4

##### **Preparation of (3S)-1-[[2-(1,3-benzodioxol-5-yl)ethyl]pyrrolidin-3-yl]cyclopentyl(hydroxy)-phenylacetate (Compound No. 4)**

##### **Step 1: Preparation of (3S)-pyrrolidin-3-yl cyclopentyl (hydroxy) phenylacetate**

The compound (3S)-1-benzylpyrrolidin-3-yl cyclopentyl (hydroxy) phenylacetate (2.8 g, 7.4 mM) was dissolved in methanol (50.0 ml) and 10% palladium on carbon was added (0.28 g) followed by the addition of ammonium formate (1.5 g, 23.8 mM) under nitrogen atmosphere. The reaction mixture was maintained at 40-50°C for 2 hours. One more lot of ammonium formate (1.5 g, 23.8 mM) was added and the reaction mixture was maintained at the same temperature for one more hour. The reaction mixture was cooled to room temperature and filtered through a bed of hyflo. The filtrate was evaporated under vacuum and the residue was taken in ethyl acetate and washed with water and brine solution and dried over anhydrous sodium sulphate and concentrated. It was used as such in the next step.

##### **Step 2: Preparation of (3S)-1-[[2-(1,3-benzodioxol-5-yl)ethyl]pyrrolidin-3-yl]cyclopentyl(hydroxy)-phenylacetate (Compound No. 4)**

The compound (3S)-pyrrolidine-3-yl cyclopentyl (hydroxy) phenylacetate (0.19 g, 0.66 mM) was dissolved in acetonitrile (5.0 ml) and 5-(2-bromoethyl)-1, 3-benzodioxole (0.18 g, 0.79 mM) was added. To the reaction mixture, potassium carbonate (0.28 g, 1.97 mM) and potassium iodide (0.22 g, 1.31 mM) were added. The reaction mixture was heated under reflux for 9 hours. The reaction mixture was cooled to room temperature and acetonitrile was evaporated under vacuum. The residue was partitioned between ethyl acetate (30.0 ml) and water (30.0 ml). The organic layer was washed with water and brine solution followed by drying over anhydrous sodium sulphate and then concentrated. The residue was purified by silica gel column chromatography using 20% methanol in chloroform to get the title compound as oil. Yield = 52% (0.15 g, 0.34 mM).

<sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 7.65 (d, J = 7.4 Hz, 2H), 7.30-7.35 (m, 3H), 6.61-6.74 (m, 3H), 5.92 (s, 2H), 5.21-5.23 (m, 1H), 3.78 (s, 1H), 2.54-2.92 (m, 7H), 2.05-2.45 (m, 2H), 1.83 (brss, -OH), 1.25-1.64 (m, 9H).

### Example 5

#### 5 Preparation of (3S)-1-[[2-(2,3-dihydro-1-benzofuran-5-yl)ethyl]pyrrolidin-3-yl]cyclopentyl(hydroxy)phenylacetate (Compound No. 5)

The compound (3S)-pyrrolidin-3-yl cyclopentyl (hydroxy) phenylacetate (0.2 g, 0.69 mM) was dissolved in acetonitrile (5.0 ml) followed by the addition of 5-(2-bromoethyl)-2, 3-dihydro-1-benzofuran (0.173 g, 0.76 mM), potassium carbonate (0.29 g, 2.01 mM) and  
10 potassium iodide (0.23 g, 1.38 mM). The reaction mixture was heated under reflux for 8 hours and then cooled to room temperature. Acetonitrile was evaporated under vacuum. The residue was partitioned between ethyl acetate (30.0 ml) and water (30.0 ml). The organic layer was washed with water and brine solution followed by drying over anhydrous sodium sulphate. The residue was purified by silica gel column  
15 chromatography using 10% methanol in chloroform to get the title compound as oil. Yield = 50% (0.15 g, 0.34 mM).

<sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 7.66 (d, J = 7 Hz, 2H), 7.31-7.36 (m, 3H), 7.03 (d, J = 8 Hz, 1H), 6.93 (t, J = 8 Hz, 1H), 6.69-6.72 (m, 1H), 5.22-5.24 (m, 1H), 4.55 (t, J = 9 Hz, 2H), 3.76 (br m, 1H), 3.18 (t, J = 9 Hz, 2H), 2.54-2.92 (m, 8H), 2.00-2.50 (m, 1H), 1.25-1.63 (m,  
20 10H, including -OH).

### Example 6

#### Preparation of (3S)-1-[(4-methyl-pent-3-enyl) pyrrolidin-3-yl]cyclopentyl (hydroxy)-phenylacetate (Compound No. 6)

The compound (3S)-pyrrolidin-3-yl cyclopentyl (hydroxy) phenylacetate (0.2 g, 0.69 mM) was dissolved in acetonitrile (5.0 ml) and 4-methyl-pent-3-enyl bromide (0.13 ml, 0.76 mM), potassium carbonate (0.29 g, 2.01 mM) and potassium iodide (0.23 g, 1.38 mM) were added into it. The reaction mixture was heated under reflux for 8 hours followed by cooling to room temperature. Acetonitrile was evaporated under vacuum. The residue was

partitioned between ethyl acetate (30.0 ml) and water (30.0 ml). The organic layer was washed with water and brine solution. It was then dried over anhydrous  $\text{Na}_2\text{SO}_4$  and concentrated. The residue was purified by silica gel column chromatography using 10% methanol in chloroform to get the title compound. Yield = 54% (0.14 g, 0.38 mM) yield.

- 5  $^1\text{H}$  NMR ( $\text{CDCl}_3$ ):  $\delta$  7.55-7.66 (m, 2H), 7.30-7.34 (m, 3H), 5.60 (m, 1H), 5.06-5.24 (m, 1H), 4.32-4.71 (m, 2H), 3.58-3.75 (m, 3H), 2.83-3.25 (m, 3H), 2.22-2.33 (m, 3H, including -OH), 1.26-1.79 (m, 15H).

### Example 7

**Preparation of (3S)-1-[[4-(trifluoromethyl)phenyl]sulfonyl]pyrrolidin-3-yl]cyclopentyl(hydroxy) phenylacetate (Compound No. 7)**

- The compound (3S)-pyrrolidin-3-yl cyclopentyl (hydroxy) phenyl acetate (0.2 g, 0.69 mM) was dissolved in chloroform (10.0 ml) and triethylamine (0.19 ml, 1.38 mM) and dimethylaminopyridine (0.001 g) were subsequently added. The reaction mixture was cooled at 0-5°C. 4-(trifluoromethyl) benzenesulfonyl chloride (0.2 g, 0.83 mM) was added to it and maintained for 2 hours at the same temperature and then at room temperature for overnight. The reaction mixture was diluted and the organic layer was washed with water and brine solution. It was finally dried over anhydrous sodium sulphate and concentrated. The residue was purified by silica gel column chromatography using 40% ethyl acetate in hexane to get the title compound. Yield = 70% (0.24 g, 0.48 mM).

- 20  $^1\text{H}$  NMR ( $\text{CDCl}_3$ ):  $\delta$  7.97-7.99 (m, 2H), 7.83-7.87 (m, 2H), 7.27-7.42 (m, 5H), 5.22-5.28 (brm, 1H), 3.32-3.57 (m, 6H), 2.50-2.75 (m, 1H), 2.08-2.10 (brss, 1H), 1.26-1.82 (m, 8H).

### Example 8

**Preparation of (3S)-1-[[4-nitrophenyl]sulfonyl]pyrrolidin-3-yl]cyclopentyl (hydroxy)phenyl acetate (Compound No. 8)**

- 25 The compound (3S)-pyrrolidin-3-yl cyclopentyl (hydroxy) phenylacetate (0.2 g, 0.69 mM) was dissolved in chloroform (10.0 ml). To the reaction mixture triethylamine (0.19 ml, 1.38 mM) and dimethylaminopyridine (0.001 g) were added and cooled the resulting

reaction mixture to 0-5°C. 4-(nitro) benzenesulfonyl chloride (0.184 g, 0.83 mM) was added to it and maintained for 2 hour and the reaction was quenched by adding saturated sodium bicarbonate solution (5.0 ml). The organic layer was washed with water and brine solution, which was dried over anhydrous sodium sulphate and concentrated. The residue  
5 was purified by silica gel column chromatography using 40% ethyl acetate in hexane to get the title compound. Yield = 76% (0.25 g, 0.53 mM).

<sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 8.37-8.43 (m, 2H), 7.99-8.07 (m, 2H), 7.29-7.44 (m, 5H), 5.23-5.27 (m, 1H), 3.28-3.60 (m, 6H), 2.50-2.75 (m, 1H), 2.10-2.13 (brs, 1H), 1.23-1.60 (m, 8H).

### Example 9

#### 10 Preparation of (3S)-1-benzylpyrrolidin-3-yl (2R)-hydroxy (3-oxocyclopentyl) phenyl acetate (Compound No. 9)

The compounds (2R)-hydroxy (3-oxocyclopentyl) phenylacetic acid (1.0 g, 4.27 mM), (3R)-1-benzyl-pyrrolidin-3-ol (0.63 g, 3.56 mM) were dissolved in dry tetrahydrofuran (30ml) and triphenylphosphine (1.12 g, 4.27 mM). To the reaction mixture, a solution of  
15 diethylazoldicarboxyate (0.7 ml, 4.27 mM) in dry tetrahydrofuran (4.0 ml) was added dropwise under nitrogen atmosphere at room temperature with constant stirring and stirring was continued for 20 hours at the same temperature. Tetrahydrofuran was evaporated under vacuum and the residue was purified by silica gel column chromatography using 35% ethyl acetate in hexane to get the title compound. Yield = 11%  
20 (0.18 g, 0.46 mM).

<sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 7.61-7.67 (m, 2H), 7.30-7.40 (m, 8H), 5.18-5.23 (m, 1H), 3.88 (brs, -OH), 3.57-3.70 (m, 2H), 3.21 (m, 1H), 2.68-2.80 (m, 3H), 2.39-2.44 (m, 1H), 2.12-2.27 (m, 4H), 1.61-1.81 (m, 4H).

### Example 10

#### 25 Preparation of (3S)-1-benzylpyrrolidin-3-yl (2R)-hydroxy (3-hydroxycyclopentyl) phenyl acetate (Compound No. 10)

The compound (3S)-1-benzylpyrrolidin-3-yl (2R)-hydroxy (3-oxocyclopentyl) phenylacetate (0.5 g, 1.27 mM) was dissolved in methanol (25.0 ml). To the reaction

mixture, sodium borohydride (0.24 g, 6.36 mM) was added in several portions at -78°C and maintained the resulting reaction mixture at the same temperature for 1 hour. The reaction mixture was diluted with water (10.0 ml) and brought to room temperature. Methanol was removed under vacuum and the organic layer was extracted with  
5 chloroform. The organic layer was washed with water and brine solution and dried over anhydrous sodium sulphate and concentrated. The residue was purified by silica gel column chromatography using 60% ethyl acetate in hexane to get the title compound. Yield = 46% (0.23 g, 0.58 mM) .

<sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 7.63-7.66 (m, 2H), 7.28-7.37 (m, 8H), 5.19-5.22 (m, 1H), 4.35 (br s, secondary -OH), 4.11-4.19 (m, 1H), 3.55-3.72 (m, 2H), 3.25 (m, 1H), 2.66-2.82 (m, 3H),  
10 2.45 (m, 1H), 2.17-2.20 (m, 1H), 1.95 (m, 1H), 1.42-1.82 (m, 7H, including quaternary -OH).

### Example 11

#### Preparation of (3S)-1-[(phenyl acetyl)]pyrrolidin-3-yl cyclopentyl(hydroxy)phenyl 15 acetate (Compound NO. 11)

The compound (3S)-pyrrolidin-3-yl cyclopentyl (hydroxy) phenyl acetate (0.2 g, 0.69 mM) was dissolved in chloroform (10.0 ml). To the reaction mixture, triethylamine (0.19 ml, 1.38 mM) and dimethyl amino pyridine (DMAP) (0.001 g) were added and cooled to 0-5°C. Phenyl acetyl chloride (0.12 ml, 0.83 mM) was added to it and maintained the  
20 resulting mixture at the same temperature for 2 hours and then at room temperature overnight. The reaction mixture was diluted with chloroform and the reaction was quenched by adding saturated sodium bicarbonate solution (5.0 ml). The organic layer was washed with water and brine solution which was finally dried over anhydrous sodium sulphate and concentrated. The residue was purified by silica gel column chromatography  
25 using 40% ethyl acetate in hexane to get the title compound. Yield = 53% (0.15 g, 0.37 mM).

<sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 7.46-7.55 (m, 2H), 7.19-7.34 (m, 8H), 5.32-5.33 (m, 1H), 3.59-3.71 (m, 4H), 3.46-3.54 (m, 2H) 2.15-2.17 (m, 1H) 1.54-1.59 (m, 2H), 1.45-1.50 (m, 7H), 1.25-1.37 (m, 2H).

### Example 12

#### Preparation of (3S)-1-[(benzyloxyacetyl)]pyrrolidin-3-yl cyclopentyl (hydroxy)phenyl acetate (Compound No. 12)

The compound (3S)-pyrrolidin-3-yl cyclopentyl (hydroxy) phenylacetate (0.2 g, 0.69 mM) was dissolved in chloroform (10.0 ml). To the reaction mixture, triethylamine (0.19 ml, 1.38 mM) and dimethyl amino pyridine (DMAP) (0.001 g) were added and cooled to 0-5°C. Benzyloxyacetyl chloride (0.14 ml, 0.83 mM) was added to it and the reaction mixture was maintained at the same temperature for two hours, then at room temperature overnight. The reaction mixture was diluted with chloroform and the reaction was quenched by adding saturated sodium bicarbonate solution (5.0 ml). The organic layer was washed with water and brine solution, dried over anhydrous sodium sulphate and concentrated. The residue was purified by silica gel column chromatography using 40% ethyl acetate in hexane to get the title compound. Yield = 66% (0.2 g, 0.46 mM).

<sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 7.53-7.59 (m, 2H), 7.25-7.38 (m, 8H), 5.34 (brn, 1H), 4.52-4.67 (m, 2H), 4.09-4.26 (m, 1H), 3.62-3.84 (m, 4H), 3.49-3.52 (m, 1H), 2.85 (brn, 1H), 1.92-2.20 (m, 2H), 47-1.54 (m, 7H), 1.26-1.34 (m, 2H).

### Example 13

#### Preparation of Benzyl (3S)-3-[2-hydroxy-2-cyclopentyl-2-phenylpropanoyl]oxy]pyrrolidine-1-carboxyate (Compound No. 13)

The compound (3S)-pyrrolidin-3-yl cyclopentyl (hydroxy) phenylacetate (0.2 g, 0.69 mM) was dissolved in chloroform (10.0 ml). To the reaction mixture, triethylamine (0.19 ml, 1.38 mM) and dimethyl amino pyridine (DMAP) (0.001) were added and cooled to 0-5°C. Benzylchloroformate (0.24 ml, 0.83 mM) was added to it and maintained the reaction mixture at the same temperature for two hours and then at room temperature overnight. The reaction mixture was diluted with chloroform and the reaction was quenched by adding saturated sodium bicarbonate solution (5.0 ml). The organic layer was washed with water and brine solution, dried over anhydrous sodium sulphate and concentrated. The residue was purified by silica gel column chromatography using 40% ethyl acetate in hexane to get the title compound. Yield = 65%(0.19g, 0.45mM).



<sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 7.57-7.61 (m, 2H), 7.30-7.38 (m, 8H), 5.32 (brm, 1H), 5.10-5.17 (m, 2H), 3.38-3.68 (m, 5H), 2.85-2.90 (brm, 1H), 2.13 (brs, 1H), 1.88-1.90 (m, 1H), 1.21-1.47 (m, 8H).

#### Example 14

##### 5 Preparation of (3S)-1-[(4-bromophenyl)]pyrrolidin-3-yl] cyclopentyl (hydroxy)phenyl acetate (Compound No. 14)

The compound (3S)-pyrrolidin-3-yl cyclopentyl(hydroxy)phenyl acetate (0.2 g, 0.69 mM) was dissolved in chloroform (10.0 ml). To the reaction mixture, triethylamine (0.19 ml, 1.38 mM) and dimethyl amino pyridine DMAP (0.001 g) were added and cooled to 0-  
10 5°C. 4-bromo benzenesulfonyl chloride (0.21 g, 0.83 mM) was added to it and the reaction mixture was maintained at the same temperature for two hours and then at room temperature overnight. The reaction mixture was diluted with chloroform and the reaction was quenched by adding saturated sodium bicarbonate solution (5.0 ml). The organic layer was washed with water and brine solution, dried over anhydrous sodium sulphate  
15 and concentrated. The residue was purified by silica gel column chromatography using 40% ethyl acetate in hexane to get the title compound as a gummy solid. Yield = 43% (0.15 g, 0.3 mM).

<sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 7.73-7.74 (m, 4H), 7.28-7.41 (m, 5H), 5.18-5.28 (brd, 1H), 3.25-3.56 (m, 5H), 2.50-2.75 (m, 1H), 2.08-2.10 (brs, 1H), 1.26-1.65 (m, 9H).

20

#### Example 15

##### Preparation of (3S)-1-benzyl-pyrrolidin-3-yl (2R)-cyclopentyl (hydroxy) phenyl acetate (Compound No. 15)

The compounds (2R)-hydroxy (3-oxocyclopentyl)-2-hydroxy-2-phenylacetic acid (3.0 g, 13.6 mM), (3R)-1-benzyl-pyrrolidin-3-ol (2.0 g, 11.4 mM) were dissolved in dry  
25 tetrahydrofuran (80.0ml) and triphenylphosphine (3.6 mM). To the reaction mixture, a solution of diisopropyl azadicarboxylate (2.7 ml, 13.6 mM) in dry tetrahydrofuran (20.0 ml) was added dropwise under nitrogen atmosphere at room temperature with constant stirring and the stirring was continued for 20 hours at room temperature. Tetrahydrofuran

was evaporated under vacuum and the residue was taken in chloroform and washed with saturated sodium bicarbonate solution, water and brine solution, dried over anhydrous sodium sulphate and concentrated. The residue was purified by silica gel column chromatography using 15% ethyl acetate in hexane to get the title compound. Yield = 23%  
5 (1.2 g, 3.17 mM).

<sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 7.65-7.67 (m, 2H), 7.26-7.36 (m, 8H), 5.16-5.21 (m, 1H), 3.56-3.75 (m, 3H), 2.70-2.81 (m, 4H), 2.50-2.60 (m, 1H), 2.10-2.30 (m, 1H), 1.26-1.90 (m, 9H).

### Example 16

#### Preparation of (3S)-1-[[2-(2,3-dihydro-1-benzofuran-5-yl)ethyl]pyrrolidin-3-yl] (2R)-cyclopentyl(hydroxy)phenyl acetate (Compound No. 16) 10

The compound (3S)-pyrrolidin-3-yl (2R)-cyclopentyl (hydroxy) phenyl acetate (0.2 g, 0.69 mM) was dissolved in acetonitrile (5.0ml). To the reaction mixture, 5-(2-bromoethyl)-2, 3-dihydro-1-benzofuran (0.173 g, 0.76 mM), potassium carbonate (0.29 g, 2.01 mM) and potassium iodide (0.23 g, 1.38 mM) were added and the reaction mixture  
15 was heated under reflux for 8 hours and then cooled to room temperature. Acetonitrile was evaporated under vacuum. The residue was partitioned between ethyl acetate (30.0 ml) and water (30.0 ml). The organic layer was washed with water and brine solution. It was dried over anhydrous Na<sub>2</sub>SO<sub>4</sub> and concentrated. The residue was purified by silica gel column chromatography using 30% ethyl acetate in hexane to get the title compound.  
20 Yield = 46% (0.14 g, 0.32 mM).

<sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 7.66 (d, J=1.5 Hz, 2H), 7.28-7.36 (m, 3H), 7.05 (d, J=8 Hz, 1H), 6.94 (d, J=8 Hz, 1H), 6.71 (d, J=8 Hz, 1H), 5.20-5.23 (m, 1H), 4.52-4.58 (m, 2H), 3.80 (s, 1H), 3.18 (t, J=9 Hz, 2H), 2.70-2.92 (m, 8H), 2.50-2.70 (m, 1H), 2.04-2.15 (m, 1H), 1.25-1.61 (m, 9H).

### Example 17

#### Preparation of (3S)-1-[[2-(1,3-benzodioxol-5-yl) ethyl]pyrrolidin-3-yl] (2R)-cyclopentyl(hydroxy)phenyl acetate (Compound No. 17)

The compound (3S)-pyrrolidin-3-yl (2R)-cyclopentyl (hydroxy) phenylacetate (0.19 g, 0.66 mM) was dissolved in acetonitrile (5.0 ml). To the reaction mixture, 5-(2-bromoethyl)-1, 3-benzodioxole (0.18 g, 0.79 mM), potassium carbonate (0.28 g, 1.97 mM) and potassium iodide (0.22 g, 1.31 mM) were added and the reaction mixture was heated under reflux for 9 hours and then cooled to room temperature. Acetonitrile was evaporated under vacuum. The residue was partitioned between ethyl acetate (30.0 ml) and water (30.0 ml). The organic layer was washed with water and brine solution, dried over anhydrous sodium sulphate and concentrated. The residue was purified by silica gel column chromatography using 30% ethyl acetate in hexane to get the title compound. Yield = 43% (0.12 g, 0.27 mM).

<sup>1</sup>H NMR (CDCl<sub>3</sub>): δ 7.65 (d, J = 7.5 Hz, 2H), 7.28-7.36 (m, 3H), 6.64-6.75 (m, 3H), 5.92 (s, 2H), 5.19-5.24 (m, 1H), 3.79 (s, 1H), 2.63-2.92 (m, 7H), 2.45-2.65 (m, 1H), 2.05-2.30 (m, 1H), 1.23-1.80 (m, 10H).

#### Biological Activity

##### **Radioligand Binding Assays:**

The affinity of test compounds for M<sub>2</sub> and M<sub>3</sub> muscarinic receptor subtypes was determined by [<sup>3</sup>H]-N-methyl scopolamine binding studies using rat heart and submandibular gland, respectively as described by Moriya et al., (*Life Sci.*, 1999,64(25): 2351-2358) with minor modifications.

**Membrane preparation:** Submandibular glands and heart were isolated and placed in ice cold homogenizing buffer (HEPES 20 mM, 10 mM EDTA, pH 7.4) immediately after sacrifice. The tissues were homogenized in 10 volumes of homogenizing buffer and the homogenate was filtered through two layers of wet gauze and filtrate was centrifuged at 500g for 10min. The supernatant was subsequently centrifuged at 40,000g for 20 min.

The pellet thus obtained was resuspended in same volume of assay buffer (HEPES 20 mM, EDTA 5 mM, pH 7.4) and were stored at -70°C until the time of assay.

**Ligand binding assay:** The compounds were dissolved and diluted in DMSO. The membrane homogenates (150-250 µg protein) were incubated in 250 µl of assay buffer (HEPES 20 mM, pH 7.4) at 24-25°C for 3 hours. Non-specific binding was determined in the presence of 1 µM atropine. The incubation was terminated by vacuum filtration over GF/B fiber filters (Wallac). The filters were then washed with ice-cold 50 mM Tris HCl buffer (pH 7.4). The filter mats were dried and bound radioactivity retained on filters was counted. The IC<sub>50</sub> & K<sub>d</sub> were estimated by using the non-linear curve-fitting program using G Pad Prism software. The value of inhibition constant K<sub>i</sub> was calculated from competitive binding studies by using Cheng & Prusoff equation (*Biochem Pharmacol*, 1973.22: 3099-3108),  $K_i = IC_{50} / (1 + L/K_d)$ , where L is the concentration of [<sup>3</sup>H]NMS used in the particular experiment.

#### **Functional Experiments using isolated rat bladder:**

##### **Methodology:**

Animal were euthanized by overdose of urethane and whole bladder was isolated and removed rapidly and placed in ice cold Tyrode buffer with the following composition (mMol/L) sodium chloride 137; KCl 2.7, CaCl<sub>2</sub> 1.8, MgCl<sub>2</sub> 0.1; NaHCO<sub>3</sub> 11.9, NaH<sub>2</sub>PO<sub>4</sub> 0.4; Glucose 5.55 and continuously gassed with 95% O<sub>2</sub> and 5% CO<sub>2</sub>.

The bladder was cut into longitudinal strips (3 mm wide and 5-6 mm long) and mounted in 10 ml organ baths at 30°C, with one end connected to the base of the tissue holder and the other end connected to a polygraph through a force displacement transducer. Each tissue was maintained at a constant basal tension of 2 g and allowed to equilibrate for 1 hour during which the PSS was changed every 15 min. At the end of equilibration period, the stabilization of the tissue contractile response was assessed with 1 µmol/L of carbachol consecutively for 2-3 times. Subsequently, a cumulative concentration response curve to carbachol (10<sup>-9</sup> mol/L to 3 x 10<sup>-5</sup> mol/L) was obtained. After several washes, once the baseline was achieved, cumulative concentration response curve was obtained in the presence of NCE (NCE added 20 min. prior to the second CRC).

The contractile results were expressed as % of control E max ED50 values were calculated by fitting a non-linear regression curve (Graph Pad Prism). pKB values were calculated by the formula  $pKB = -\log [(molar\ concentration\ of\ antagonist / (dose\ ratio - 1))]$

where,

- 5 dose ratio = ED50 in the presence of antagonist / ED50 in the absence of antagonist.

The results of the in-vitro tests are listed in Table II.

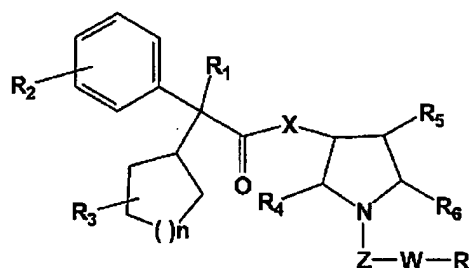
#### *In-vitro* Test

	Table II Receptor Binding Assay		Functional Assay pK <sub>B</sub>
	M <sub>2</sub> PKi	M <sub>3</sub> pki	
Compound No.1	<5	<5	-
Compound No.2	5.75	6.97	-
Compound No.3	6.13	7.17	7.54
Compound No.4	7.32	8.39	7.36
Compound No.5	6.93	8.02	8.69
Compound No.6	6.74	7.87	7.84
Compound No.7	6.82	7.39	-
Compound No.8	6.58	7.25	-
Compound No.9	<5	6.9	-
Compound No.10	5.33	6.81	-
Compound No.11	<6	<6	-
Compound No.12	6.74	7.34	-
Compound No.13	6.39	6.7	-
Compound No.14	6.77	7.4	-
Compound No.15	6.6	8.0	-
Compound No.16	6.9	8.0	-
Compound No.17	7.4	8.5	-
Oxybutynin	8.00	9.46	8.93
Tolterodine	8.16	8.15	8.89

- 10 While the present invention has been described in terms of its specific embodiments, certain modifications and equivalents will be apparent to those skilled in the art and are intended to be included within the scope of the present invention.

## We Claim

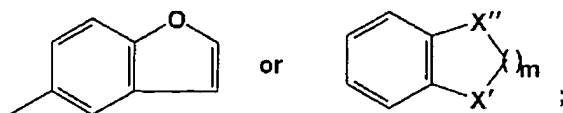
1. A compound having the structure of Formula I:



Formula I

and its pharmaceutically acceptable salts, pharmaceutically acceptable solvates, esters, enantiomers, diastereomers, N-oxides, polymorphs, prodrugs or metabolites, wherein

- X represents an oxo, amino, lower alkyl(C<sub>1</sub>-C<sub>4</sub>)amino or lower alkoxy (C<sub>1</sub>-C<sub>4</sub>);
- R<sub>1</sub> represents hydroxy, amino, or alkoxy (OR<sub>7</sub>), wherein R<sub>7</sub> represents lower alkyl;
- R<sub>2</sub> represents hydrogen, halogen (e.g. fluorine, chlorine, bromine and iodine) or lower alkyl;
- R<sub>3</sub> represents hydrogen, keto, hydroxy, sulphonyl methane, tosyl, azide, amino or substituted amine (NHR<sub>8</sub>) where R<sub>8</sub> represents hydrogen or YR<sub>9</sub>, wherein R<sub>9</sub> represents benzyl, benzyloxy, alkyl, benzyl ether, phenyl optionally substituted with alkyl, trifluoromethyl, nitro or halogen (e.g. fluorine, chlorine, bromine, iodine);
- Z represents methylene, sulphonyl or carbonyl;
- W represents a direct link of (CH<sub>2</sub>)<sub>n</sub>, where n is 1 or 2, lower alkoxy (C<sub>1</sub>-C<sub>4</sub>) or lower thioalkoxy (C<sub>1</sub>-C<sub>4</sub>);
- R represents alkyl, aryl, aralkyl, benzyl ether, dimethyl ether, methoxy methyl, benzyl methyl ether or phenyl optionally substituted with alkyl, halogen (e.g. fluorine, chlorine, bromine, iodine), nitro, heterocycle selected from the group consisting of pyridinyl, pyrazinyl or thienyl;



wherein X' and X'' are each independently selected from the group consisting of oxygen, methylene; m represents 1 to 3; and

R<sub>4</sub>, R<sub>5</sub> and R<sub>6</sub> represent hydrogen or lower alkyl.

5

2. A compound selected from the group consisting of:

2-cyclopentyl-2-hydroxy-N-[(3S)-1-benzyl-pyrrolidin-3-yl]-2-phenyl acetamide

2-cyclopentyl-2-hydroxy-N-[(3S)-1-[2-(1,3-benzodioxol-5-yl)ethyl]pyrrolidin-3-yl]-2-phenyl acetamide

10 (3S)-1-benzylpyrrolidin-3-yl cyclopentyl (hydroxy) phenyl acetate

(3S)-1-[[2-(1,3-benzodioxol-yl) ethyl]pyrrolidin-3-yl]cyclopentyl (hydroxy) phenyl acetate

(3S)-1-[[2-(2,3-dihydro-1-benzofuran-5-yl) ethyl]pyrrolidin-3-yl]cyclopentyl (hydroxy)phenyl acetate

15 (3S)-1-[(4-methyl-pent-3-enyl) pyrrolidin-3-yl] cyclopentyl (hydroxy) phenyl acetate

(3S)-1-[(4-trifluoromethylphenyl)sulfonyl]pyrrolidin-3-yl]cyclopentyl (hydroxy) phenyl acetate

20 (3S)-1-[(4-nitrophenyl)sulfonyl]pyrrolidin-3-yl]cyclopentyl (hydroxy) phenyl acetate

(3S)-1-benzyl-pyrrolidin-3-yl (2R)-hydroxy (3-oxocyclopentyl) phenyl acetate

(3S)-1-benzyl-pyrrolidin-3-yl (2R)-hydroxy (3-hydroxycyclopentyl) phenyl acetate

(3S)-1-[(phenyl acetyl) pyrrolidin-3-yl]cyclopentyl (hydroxy) phenyl acetate

(3S)-1-[(benzyloxy) acetyl]]pyrrolidin-3-yl]cyclopentyl (hydroxy) phenyl acetate

25 Benzyl (3S)-3-[(2-hydroxy-2-cyclopentyl-2-phenylpropanoyl) oxy]pyrrolidin-1-carboxylate

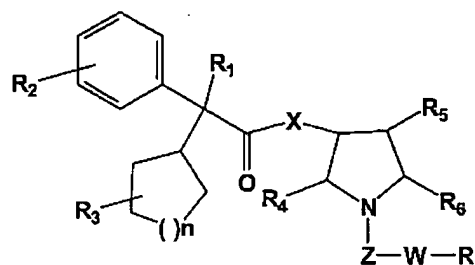
(3S)-1-[(4-bromophenyl) sulfonyl]pyrrolidin-3-yl]cyclopentyl (hydroxy) phenyl acetate

(3S)-1-benzyl-pyrrolidin-3-yl (2R)-cyclopentyl (hydroxy) phenyl acetate

30 (3S)-1-[[2-(2,3-dihydro-1-benzofuran-5-yl) ethyl]pyrrolidin-3-yl](2R)-cyclopentyl(hydroxy) phenyl acetate

(3S)-1-[[2-(1,3-benzodioxol-5-yl) ethyl]pyrrolidin-3-yl](2R)-cyclopentyl  
(hydroxy)phenyl acetate

3. A pharmaceutical composition comprising a therapeutically effective amount of a  
5 compound as defined in claim 1 or 2 optionally together with pharmaceutically  
acceptable carriers, excipients or diluents.
4. A method for treatment or prophylaxis of an animal or a human suffering from a  
disease or disorder of the respiratory, urinary and gastrointestinal systems, wherein the  
10 disease or disorder is mediated through muscarinic receptors, comprising  
administering to said animal or human, a therapeutically effective amount of a  
compound having the structure of Formula I,



Formula I

20 or its pharmaceutically acceptable salts, pharmaceutically acceptable solvates, esters,  
enantiomers, diastereomers, N-oxides, polymorphs, prodrugs or metabolites, wherein

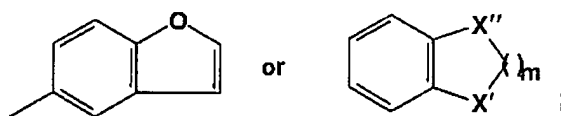
- X represents an oxo, amino, lower alkyl(C<sub>1</sub>-C<sub>4</sub>)amino or lower alkoxy (C<sub>1</sub>-C<sub>4</sub>);
- 25 R<sub>1</sub> represents hydroxy, amino, or alkoxy (OR<sub>7</sub>), wherein R<sub>7</sub> represents lower alkyl;
- R<sub>2</sub> represents hydrogen, halogen (e.g. fluorine, chlorine, bromine and iodine) or lower  
alkyl;
- R<sub>3</sub> represents hydrogen, keto, hydroxy, sulphonyl methane, tosyl, azide, amino or  
substituted amine (NHR<sub>8</sub>) where R<sub>8</sub> represents hydrogen or YR<sub>9</sub>, wherein R<sub>9</sub>  
30 represents benzyl, benzyloxy, alkyl, benzyl ether, phenyl optionally substituted  
with alkyl, trifluoromethyl, nitro or halogen (e.g. fluorine, chlorine, bromine,  
iodine);



Z represents methylene, sulphonyl or carbonyl;

W represents a direct link of  $(CH_2)_n$ , where n is 1 or 2, lower alkoxy ( $C_1-C_4$ ) or lower thioalkoxy ( $C_1-C_4$ );

5 R represents alkyl, aryl, aralkyl, benzyl ether, dimethyl ether, methoxy methyl, benzyl methyl ether or phenyl optionally substituted with alkyl, halogen (fluorine, chlorine, bromine, iodine), nitro, heterocycle selected from the group consisting of pyridinyl, pyrazinyl or thienyl;



10 wherein  $X'$  and  $X''$  are each independently selected from the group consisting of oxygen, methylene; and m represents 1 to 3; and

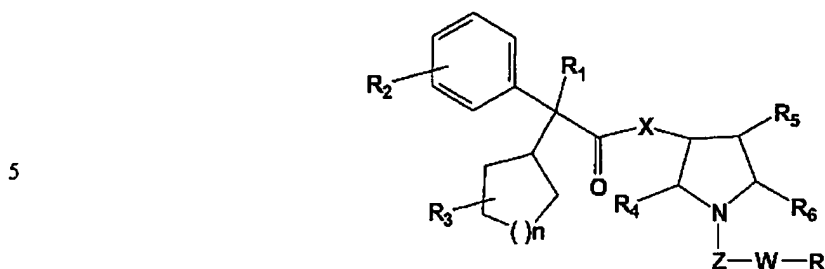
$R_4$ ,  $R_5$  and  $R_6$  represent hydrogen or lower alkyl.

5. The method according to claim 4 wherein the disease or disorder is urinary  
15 incontinence, lower urinary tract symptoms (LUTS), bronchial asthma, chronic obstructive pulmonary disorders (COPD), pulmonary fibrosis, irritable bowel syndrome, obesity, diabetes or gastrointestinal hyperkinesis.

6. The method for treatment or prophylaxis of an animal or a human suffering from a  
20 disease or disorder of the respiratory, urinary and gastrointestinal systems, where the disease or disorder is mediated through muscarinic receptors, comprising administering to said animal or human, a therapeutically effective amount of the pharmaceutical composition according to the claim 3.

25 7. The method according to claim 6 wherein the disease or disorder is urinary incontinence, lower urinary tract symptoms (LUTS), bronchial asthma, chronic obstructive pulmonary disorders (COPD), pulmonary fibrosis, irritable bowel syndrome, obesity, diabetes and gastrointestinal hyperkinesis.

8. A process of preparing a compound of Formula I



Formula I

and its pharmaceutically acceptable salts, pharmaceutically acceptable solvates, esters,  
10 enantiomers, diastereomers, N-oxides, polymorphs, prodrugs or metabolites, wherein

X represents an oxo, amino, lower alkyl(C<sub>1</sub>-C<sub>4</sub>)amino or lower alkoxy (C<sub>1</sub>-C<sub>4</sub>);

R<sub>1</sub> represents hydroxy, amino, or alkoxy (OR<sub>7</sub>), wherein R<sub>7</sub> represents lower alkyl;

15 R<sub>2</sub> represents hydrogen, halogen (e.g. fluorine, chlorine, bromine and iodine) or lower alkyl;

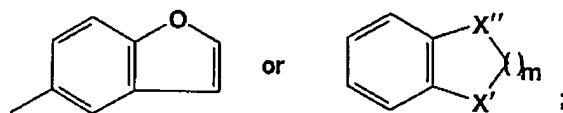
R<sub>3</sub> represents hydrogen, keto, hydroxy, sulphonyl methane, tosyl, azide, amino or substituted amine (NHR<sub>8</sub>) where R<sub>8</sub> represents hydrogen or YR<sub>9</sub>, wherein R<sub>9</sub> represents benzyl, benzyloxy, alkyl, benzyl ether, phenyl optionally substituted with alkyl, trifluoromethyl, nitro or halogen (e.g. fluorine, chlorine, bromine, iodine);  
20

Z represents methylene, sulphonyl or carbonyl;

W represents a direct link of (CH<sub>2</sub>)<sub>n</sub>, where n is 1 or 2, lower alkoxy (C<sub>1</sub>-C<sub>4</sub>) or lower thioalkoxy (C<sub>1</sub>-C<sub>4</sub>);

R represents alkyl, aryl, aralkyl, benzyl ether, dimethyl ether, methoxy methyl, benzyl methyl ether or phenyl optionally substituted with alkyl, halogen (e.g. fluorine, chlorine, bromine, iodine), nitro, heterocycle selected from the group consisting of pyridinyl, pyrazinyl or thienyl;

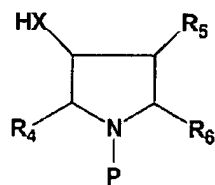
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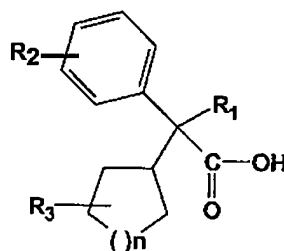
wherein  $X'$  and  $X''$  are each independently selected from the group consisting of oxygen, methylene;  $m$  represents 1 to 3; and

$R_4$ ,  $R_5$  and  $R_6$  represent hydrogen or lower alkyl, comprising

10 (a) coupling a compound of Formula II with a compound of Formula III



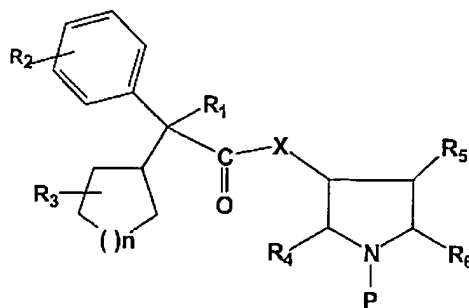
Formula II



Formula III

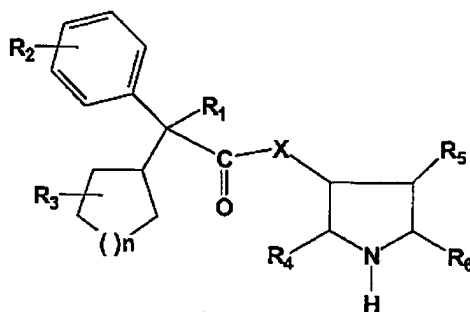
15 wherein  $R_1$ ,  $R_2$ ,  $R_3$ ,  $R_4$ ,  $R_5$ ,  $R_6$ ,  $n$  and  $X$  are the same as defined earlier and  $P$  is a protecting group, to give a compound of Formula IV,

20



Formula IV

- (b) deprotecting the compound of Formula IV in the presence of a deprotecting agent to give the compound of Formula V



Formula V

wherein R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>, R<sub>4</sub>, R<sub>5</sub>, R<sub>6</sub>, X and n are the same as defined earlier, and

- (c) N-alkylating/carbonylating or sulphonating the compound of Formula V with the compound of Formula L-Z-W-R wherein L is a leaving group and Z, W, R are the same as defined earlier, to give a compound of Formula I.
9. The process according to claim 8 wherein the reaction of a compound of Formula II with a compound of Formula III to give a compound of Formula IV is carried out in the presence of a coupling agent selected from the group consisting of N-methyl morphine, hydroxy benzotriazole, 1-(3-dimethyl amino propyl)-3-ethyl carbodiimide hydrochloride (EDC.HCL) and 1,8-diazabicyclo [5.4.0] undec-7-ene (DBU).
10. The process according to claim 8 wherein the reaction of a compound of Formula II with a compound of Formula III to give a compound of Formula IV is carried out in a suitable solvent selected from the group consisting of N, N dimethylformamide, chloroform, dimethylsulphoxide, xylene and toluene.
11. The process according to claim 8 wherein the protecting group P is selected from the group consisting of benzyl and t-butyloxy carbonyl.
12. The process according to claim 8 wherein the deprotection of a compound of Formula IV is carried out with a deprotecting agent which is selected from the group consisting of palladium on carbon, ammonium formate, trifluoroacetic acid and hydrochloric acid.

13. The process according to claim 8 wherein the deprotection of a compound of Formula IV is carried out in a suitable organic solvent selected from the group consisting of methanol, ethanol, tetrahydrofuran and acetonitrile.
- 5 14. The process according to claim 8 wherein the deprotection of a compound of Formula IV is carried out a temperature ranging from about 10-50°C.
- 10 15. The process according to claim 8 wherein the N-alkylation, carbonylation or sulphonylation of a compound of Formula V to give a compound of Formula I is carried out with a suitable alkylating, carbonylating, or sulphonylating agent of Formula L-Z-W-R wherein L is any leaving group and Z, W and R are the same as defined earlier.
- 15 16. The process according to claim 15 wherein the N-alkylation, carbonylation or sulphonylation of a compound of Formula V is carried out in a suitable solvent selected from the group consisting of N,N-dimethylformamide, dimethylsulfoxide, tetrahydrofuran, acetonitrile and dichloromethane.
- 20 17. The process according to claim 15 wherein the leaving group L is selected from the group consisting of halogen, O-tosyl, O-mestyl and benzyl.

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/IB 02/05590

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C07D207/14 C07D405/12 C07D207/12 A61K31/40 A61K31/4025  
A61P11/00 A61P13/00 A61P3/04 A61P3/10

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C07D A61K A61P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, CHEM ABS Data, BEILSTEIN Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 091 570 A (BIEL JOHN H) 28 May 1963 (1963-05-28) example 2 column 2, line 26 - line 38 column 3, line 12 - line 32	1-17
X	US 2 956 062 A (LUNSFORD CARL D) 11 October 1960 (1960-10-11) table I column 2, line 3 - line 8 -/-	1-17

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

### \* Special categories of cited documents:

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
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- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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Date of the actual completion of the international search

20 January 2004

Date of mailing of the international search report

29. 01 2004

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Seitner, I

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/IB 02/05590

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	BERNARD V. FRANKO ET AL: "Derivatives of 3-Pyrrolidinols-III. The Chemistry, Pharmacology, and Toxicology of some N-Substituted-3-Pyrrolidyl alpha-Substituted Phenylacetates" JOURNAL OF MEDICINAL AND PHARMACEUTICAL CHEMISTRY, vol. 2, 1960, pages 523-529, XP008021298 examples 504,379,371,372,480,479,484,487,485; table I page 534 -page 538 ---	1-17
X	BIEL J H ET AL: "CENTRAL STIMULANTS. II. CHOLINERGIC BLOCKING AGENTS" JOURNAL OF ORGANIC CHEMISTRY, AMERICAN CHEMICAL SOCIETY. EASTON, US, vol. 26, 1961, pages 4096-4103, XP002067288 ISSN: 0022-3263 abstract examples 1,3; table II examples 11,13; table III ---	1-17
X	EP 0 012 071 A (SYNTEX INC) 11 June 1980 (1980-06-11) example 3 page 10, line 32-35 ---	1,2
Y	EGLER R M ET AL: "MUSCARINIC RECEPTOR LIGANDS AND THEIR THERAPEUTIC POTENTIAL" CURRENT OPINION IN CHEMICAL BIOLOGY, CURRENT BIOLOGY LTD, LONDON, GB, vol. 3, no. 4, August 1999 (1999-08), pages 426-432, XP000972296 ISSN: 1367-5931 cited in the application abstract figures 3,4 ---	1-17
Y	EP 0 388 054 A (PFIZER LTD ;PFIZER (US)) 19 September 1990 (1990-09-19) cited in the application examples 4-8 claims 11,12 ---	1-17
Y	WO 98 21183 A (NOE CHRISTIAN R ;WELBROECK MAGALI (BE); LAMBRECHT GUENTER (DE); C) 22 May 1998 (1998-05-22) examples 1,2 claims 1,17,18 ---	1-17

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## INTERNATIONAL SEARCH REPORT

International Application No.

PCT/IB 02/05590

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0 823 423 A (BANYU PHARMA CO LTD) 11 February 1998 (1998-02-11) cited in the application examples 2,12,17,28,29,7120; table 1 claims 10,11	1-17
Y	WO 02 04402 A (BANYU PHARMA CO LTD ;MATSUDA KENJI (JP); KURIHARA HIDEKI (JP); OGI) 17 January 2002 (2002-01-17) -& EP 1 302 458 A (BANYU PHARMA CO LTD) 16 April 2003 (2003-04-16) examples 16-24,27-30,40 claims 40,41	1-17
Y	YUFU SAGARA ET AL: "Cyclohexylmethylpiperidinyltriphenylpropi onamide: a selective muscarinic M3 antagonist discriminating against the other receptor subtypes" JOURNAL OF MEDICINAL CHEMISTRY, AMERICAN CHEMICAL SOCIETY, WASHINGTON, US, vol. 45, no. 4, 2002, pages 984-987, XP002238502 ISSN: 0022-2623 cited in the application abstract figure 1	1-17
Y	US 6 174 900 B1 (TAKAHASHI YOSHINORI ET AL) 16 January 2001 (2001-01-16) cited in the application tables 1,2 examples 1,4 claim 6	1-17
Y	EP 0 863 141 A (BANYU PHARMA CO LTD) 9 September 1998 (1998-09-09) cited in the application claims 5,6; example 1	1-17
Y	EP 0 930 298 A (BANYU PHARMA CO LTD) 21 July 1999 (1999-07-21) examples 16-18,29 claims 14-16	1-17
	--- -/-	



## INTERNATIONAL SEARCH REPORT

International Application No

PCT/IB 02/05590

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	TANIGUCHI K ET AL: "AGENTS FOR THE TREATMENT OF OVERACTIVE DETRUSOR. VI. SYNTHESIS AND PHARMACOLOGICAL PROPERTIES OF ACETAMIDE DERIVATIVES BEARING CYCLIC AMINES IN N-SUBSTITUENTS" CHEMICAL AND PHARMACEUTICAL BULLETIN, PHARMACEUTICAL SOCIETY OF JAPAN. TOKYO, JP, vol. 42, no. 1, 1994, pages 74-84, XP002067286 ISSN: 0009-2363 examples 4C-4G column 1	1-17
X	O'NEILL, JOHN J. ET AL: "Biochemical effects of psychotomimetic anticholinergic drugs" ADVANCES IN BIOCHEMICAL PSYCHOPHARMACOLOGY (1972), 6, 203-18 , XP008026629 page 203 -page 204	1-17

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/IB 02/05590

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:  
Although claims 4-7 are directed to a method of treatment of the human/animal body, the search has been carried out and based on the alleged effects of the compound/composition.
2. ☒ Claims Nos.: 1 and 4 (part.)  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:  
see FURTHER INFORMATION sheet PCT/ISA/210
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

This International Searching Authority found multiple inventions in this International application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-17 (all partially)

Compounds according to formula (I) of claim 1 in which X represents oxo as well as their pharmaceutical use and compositions and the process for making them.

2. Claims: 1-17 (all partially)

Compounds according to formula (I) of claim 1 in which X represents amino as well as their pharmaceutical use and compositions and the process for making them.

3. Claims: 1, 3-17 (all partially)

Compounds according to formula (I) of claim 1 in which X represents lower alkyl(C1-C4)amino as well as their pharmaceutical use and compositions and the process for making them.

4. Claims: 1, 3-17 (all partially)

Compounds according to formula (I) of claim 1 in which X represents lower alkoxy (C1-C4) as well as their pharmaceutical use and compositions and the process for making them.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 1 and 4 (part.)

The scope of claims 1 and 4, in as far as the expressions "prodrugs and metabolites" are concerned, is so unclear (Article 6 PCT), that a meaningful International Search is impossible with regard to these expressions.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/IB 02/05590

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 3091570	A	28-05-1963	NONE		
US 2956062	A	11-10-1960	NONE		
EP 0012071	A	11-06-1980	US	4208423 A	17-06-1980
			AU	5310279 A	12-06-1980
			EP	0012071 A1	11-06-1980
			ES	486156 A1	16-09-1980
			JP	55105684 A	13-08-1980
			ZA	7906220 A	24-06-1981
EP 0388054	A	19-09-1990	AT	96783 T	15-11-1993
			AU	614224 B2	22-08-1991
			AU	5140290 A	20-09-1990
			BA	98300 A	14-09-2001
			CA	2012295 A1	17-09-1990
			CN	1045580 A ,B	26-09-1990
			CZ	9001295 A3	17-05-1995
			CY	1812 A	20-10-1995
			DD	292911 A5	14-08-1991
			DE	69004302 D1	09-12-1993
			DE	69004302 T2	24-02-1994
			DK	388054 T3	06-12-1993
			EG	18951 A	30-03-1994
			EP	0388054 A1	19-09-1990
			ES	2060020 T3	16-11-1994
			FI	95573 B	15-11-1995
			HK	130294 A	02-12-1994
			HU	58313 A2	28-02-1992
			HU	9500505 A3	30-10-1995
			IE	62515 B1	08-02-1995
			IL	93694 A	26-08-1994
			JP	2032393 C	19-03-1996
			JP	2282360 A	19-11-1990
			JP	7064809 B	12-07-1995
			JP	7149640 A	13-06-1995
			KR	9615142 B1	01-11-1996
			MX	19890 A	01-08-1993
			NO	901241 A ,B,	18-09-1990
			NZ	232958 A	26-05-1992
			PL	164136 B1	30-06-1994
			PT	93443 A ,B	07-11-1990
			SG	143394 G	13-01-1995
			SK	129590 A3	07-05-1997
			SU	1833374 A3	07-08-1993
			RU	2015965 C1	15-07-1994
			US	5096890 A	17-03-1992
			US	5233053 A	03-08-1993
			ZA	9001982 A	30-10-1991
WO 9821183	A	22-05-1998	WO	9821183 A1	22-05-1998
			AT	238280 T	15-05-2003
			AU	745331 B2	21-03-2002
			AU	4856097 A	03-06-1998
			CA	2271276 A1	22-05-1998
			CN	1237159 A	01-12-1999
			DE	59709927 D1	28-05-2003
			DK	937041 T3	11-08-2003

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/IB 02/05590

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9821183	A	EP 1371645 A1	17-12-2003
		EP 1369414 A1	10-12-2003
		EP 0937041 A1	25-08-1999
		ES 2195121 T3	01-12-2003
		HU 9903791 A2	28-03-2000
		JP 2001504459 T	03-04-2001
		NO 991056 A	11-05-1999
		NZ 336202 A	27-10-2000
		PL 332595 A1	27-09-1999
		PT 937041 T	30-09-2003
		SI 937041 T1	31-10-2003
		US 6307060 B1	23-10-2001
		US 2003220400 A1	27-11-2003
		US 2002173536 A1	21-11-2002
EP 0823423	A 11-02-1998	AU 700837 B2	14-01-1999
		AU 5513996 A	18-11-1996
		EP 0823423 A1	11-02-1998
		JP 2993124 B2	20-12-1999
		US 5750540 A	12-05-1998
		CA 2218479 A1	31-10-1996
		WO 9633973 A1	31-10-1996
WO 0204402	A 17-01-2002	AU 7102701 A	21-01-2002
		CA 2415468 A1	10-01-2003
		EP 1302458 A1	16-04-2003
		WO 0204402 A1	17-01-2002
US 6174900	B1 16-01-2001	CA 2179574 A1	27-12-1996
		CN 1141916 A ,B	05-02-1997
		DE 69620306 D1	08-05-2002
		DE 69620306 T2	14-11-2002
		EP 0751127 A1	02-01-1997
		JP 9071563 A	18-03-1997
		KR 254105 B1	01-05-2000
		TW 393466 B	11-06-2000
		US 5968956 A	19-10-1999
EP 0863141	A 09-09-1998	AT 205490 T	15-09-2001
		AU 7145996 A	30-04-1997
		DE 69615214 D1	18-10-2001
		DE 69615214 T2	27-06-2002
		EP 0863141 A1	09-09-1998
		US 6130232 A	10-10-2000
		CA 2234619 A1	17-04-1997
		WO 9713766 A1	17-04-1997
EP 0930298	A 21-07-1999	AT 229941 T	15-01-2003
		AU 716050 B2	17-02-2000
		AU 3635197 A	25-02-1998
		BG 103114 A	30-11-1999
		BR 9711108 A	17-08-1999
		CA 2261680 A1	12-02-1998
		DE 69718026 D1	30-01-2003
		DE 69718026 T2	10-07-2003
		EE 9900038 A	16-08-1999
		EP 0930298 A1	21-07-1999
		JP 3063164 B2	12-07-2000

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/IB 02/05590

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0930298	A	NO 990472 A	01-02-1999
		NZ 333842 A	25-05-2001
		SK 12299 A3	16-05-2000
		CN 1226888 A	25-08-1999
		CZ 9900331 A3	14-07-1999
		ES 2188961 T3	01-07-2003
		HR 970426 A1	31-08-1998
		HU 9902381 A2	29-11-1999
		ID 17259 A	11-12-1997
		WO 9805641 A1	12-02-1998
		JP 3282617 B2	20-05-2002
		JP 2000178231 A	27-06-2000
		JP 3282618 B2	20-05-2002
		JP 2000169449 A	20-06-2000
		KR 2000022214 A	25-04-2000
		PL 331431 A1	19-07-1999
		TR 9900204 T2	21-01-2000
		TR 200001482 T2	21-11-2000
		US 6040449 A	21-03-2000
		US 5948792 A	07-09-1999
		ZA 9706813 A	11-02-1998